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ABSTRACT

The objectives and design of a 3-year study of research training and supervision in biology and physics are discussed. Scientific problems arising from work on the thesis will be a focus for the postgraduate students and their supervisors. Attention will be focused on supervisors' and students' conceptions of science, subject range, research, knowledge, supervision, conditions of research, and research training. The analysis involves: observing research groups in their daily work; analyzing students' diaries; and interviewing students and supervisors about their conceptions of science, research, and knowledge. The theoretical framework will be the phenomenographical approach, which is the pedagogical research approach developed at the Department of Education, University of Gothenburg. The background for the study is considered, along with perspectives based on pedagogics and the theory of science. Also included is a review of the literature in education, psychology, the theory of science, the history of science, philosophy, and sociology. (SW)

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NEW PROJECT

TITLE OF PROJECT: SUBJECT DIDACTIC STUDIES OF RESEARCH TRAINING IN BIOLOGY AND PHYSICS

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ABSTRACT

From a content-related pedagogical perspective, this project will study research training and primarily supervision in three disciplines, two in biology and one in physics. The main object of study is the interplay between the post-graduate student and his supervisor and their interaction with the body of knowledge actualized by the student's scientific problems in the work with his thesis. Conceptions of science, concept, subject range, research, knowledge, research training, supervision, conceptual difficulties, conditions of research and research training and the target of research training are expressed and transferred in this situation, which is also part of the research process.

The purposes are as follows:

To chart the content of conceptions entertained by supervisors and students of research training, by means of interview studies and relate these conceptions to their conceptions of subject range, knowledge, science and research.

By means of participating studies in research groups, to chart aspects of the content of research training and the relation between supervisor and student in their interaction with the cognitive system of the discipline, with reference to problems arising in the student's thesis.

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To study the outward conditions applying to research training within the subject fields selected.

To compare the results in order to gain more fundamental insights for discussion in a theoretical context.

The theoretical framework comprises the pedagogical research approach developed at the Department of Education, University of Gothenburg, by the INOM-group - the phenomenographical approach. The qualitative view of pedagogical knowledge development is expressed in the interview method and in the process of analysis which lead to descriptions of certain phenomena, principles or concepts. The subject educational focus developed by us at the INOM-group, and emanating from the theory of science created at the University of Gothenburg, is combined with participating study methods. These approaches to the study of pedagogical processes supplement those dealing with organisational and economic aspects.

A survey of relevant literature in education, psychology, the theory of science, the history of science, philosophy and sociology will be presented. At the moment, theoretical perspectives of research training and supervision are lacking in the fields of education and psychology. Such perspectives and theories ought to be developed by an inter-disciplinary approach with content-related outlooks. The studies in the sociology of science, for instance, have traced phenomena revealing valuable methodological issues.

BACKGROUND

The Swedish Research on Higher Education program has several times arranged conferences where research and research training have been in focus (UKÄ, 1973; UHÄ, 1980, 1981, 1982, 1983). Strömberg Sölveborn has summarized the Swedish debate on research training in her studies. Various aspects on research training in several disciplines at universities and colleges have also been studied (e.g. Jense, 1980, 1982, 1983a,b; Stadin, Carlsson, Magnusson & Ekehammar, 1982; RRV, 1982; Ekehammar, Löfgren & Deregård, 1983; Strömberg Söveborn, 1983). Economic and organisational issues have been surveyed by means of questionnaire studies as well as interview studies. Interesting are also the pedagogical problems with research training and especially with the supervision of post-graduate students.

These studies have provided us with valuable views, although they do not treat the content of research training and how this content is transferred from supervisor to student in the act of supervision. We mean that it is necessary to supplement these studies with a content-related pedagogical study of the particular kind of teaching that supervision is. Pedagogical and psychological aspects of this act of teaching are little known and the descriptions of these aspects are indirect. In one of his studies Jense points out that "If the formal frequency of supervision does not

explain much of the effects of supervision, one might ask oneself what secrets lie behind good supervision or not" (1983a, p 67). One important research task is therefore to study the phenomenon of supervision *in situ*. These are phenomena which must be studied with other methods than have hitherto been applied.

Formal courses and literature studies are the parts of the research training which are most similar to traditional forms of teaching. The content is well defined and known to the teacher. The demands on the student are so to speak already known, though these demands can be difficult enough, when the students confront the cognitive system of the discipline.

Supervision, however, is different in nature, since no obvious result is visible regarding the questions put by the problems of research in the student's thesis. The supervision is a challenge to both teacher and student. The supervisor wants to transfer his views of how research should be carried out, with background in his total experience. It is probable that the paradigm governing the supervisor's and the student's activities in a certain research community is transferred to a greater extent in the process of supervision than in other forms of teaching. We should also mention that supervision is given in many different contexts and by others than the formal supervisor as well.

PERSPECTIVES BASED ON PEDAGOGICS AND THE THEORY OF SCIENCE

The aspects of research training and supervision that we plan to study are governed by the particular perspectives based on the theory of science and pedagogics. These perspectives form the background for our subject-didactic research.

A content-related pedagogical perspective has gradually been developed by the INOM-group, Department of Education, University of Gothenburg. This approach meant a break with the prevalent views claiming a quantitative approach to phenomena of learning. This shift of paradigm implies that the effects of learning cannot be quantified in "how much" but are qualitative in "what" and "how". The focus on *what is learnt* and *how it is learnt* brings about an emphasis on the content and the act of learning. Phenomena like knowledge, learning and teaching must be described in terms of the subject matter, i.e. the focus of the student's attention in a certain situation (Marton, 1975; Dahlgren, 1975; Säljö, 1975; Svensson, 1976; Marton, Dahlgren, Svensson & Säljö, 1977).

Characteristic of the work done by the INOM-group is the method of interviewing and analysing interview data. The method has been described in the works mentioned above and is continuously developed. The interviews are transcribed and the protocols interpreted and analysed. Such an analysis will establish categories of description, concerning various conceptions of knowledge as the qualitative differences in conceptions of a certain content. Such descriptions form an outcome space of conceptions and forms of

thought about a certain phenomenon and form a result as such. Several studies have shown the productivity of this pedagogical perspective of knowledge formation now called phenomenography (Marton, 1981).

In the early 1970's, we started to establish a subject didactic theory for science education with a background in the theory of science created by professor Håkan Törnebohm, University of Gothenburg. Since 1975 we have continued this work at the INOM-group and a subject didactic theory for science and mathematics with a basis in empirical research on the Integrated Upper Secondary School has been developed (Lybeck, 1981). We have used the interview method developed by the INOM-group and the outcome of the interview studies has been employed as tools in describing and interpreting phenomena of learning and teaching, recorded in class-rooms and school laboratories. This is a methodological development of the research approach of the INOM-group.

The platform of the theory of science and research, created by professor Törnebohm, provides us with conceptual instruments to analyse and understand science, e.g. such concepts as thematical discussion, running research programme and paradigm. Törnebohm (1976) has claimed the necessity for a study of the theory of science as part of research training. His paradigm concept is here of special interest. It contains a view of science based in evaluation, a direction of research or methodology, a conception of reality or world-picture, and a conception of research-roles, i.e. what tasks should be tackled and how. Törnebohm has related his theory of science and research to studies of theorists and philosophers of science such as Popper, Lakatos, Kuhn, Holton, Bunge, Reichenbach, Stegmüller, Spinner and Toulmin, to mention a few. Holton's (1973, 1978) thematical concept is to be found in a refined form in Törnebohm's works, as is Kuhn's concept of paradigm (1970, 1977). Kuhn's work reminds us of Fleck's (1935, 1979) concepts of "Denkstil" and "Denkkollektiv". Törnebohm has accomplished a number of case studies in physics as well as theoretical studies (Törnebohm 1977, 1978a,b, 1979, 1980, a,b, 1981a,b, 1982, 1983).

Relevant studies giving us valuable aspects on our research task are carried out internationally in disciplines such as education, psychology, philosophy, sociology, theory of science and history of science. Especially the sociology of science deals with empirical studies of research. These studies are carried out from several various theoretical perspectives and with different methods. Our content-related perspective gives us concepts to evaluate these results and research methods for the empirical studies.

THE PURPOSE AND OBJECT OF THE PROJECT

According to our particular perspective, supervision is regarded as an integrated part of research. A study of supervision contains a study of research. In this part of the research training, supervisor and student express knowledge, knowing and conceptions about

science, subject range, research, knowledge (formation of knowledge and concepts), aid sciences, supervision, research training and conceptual difficulties, conditions for research and research training as well as the aims of research training.

We have little knowledge of what these conceptions of the phenomena mentioned are, when expressed in the process of research training. Even less known is the shape that phenomena like supervision and research take, when described through the supervisor's and the student's conceptions.

The empirical studies are of two kinds. Firstly, three research groups will be followed in their daily work through observations *in situ*. Secondly, other groups of students and supervisors will be interviewed about their conceptions of the above mentioned phenomena. It is our intention that the studies *in situ* should provide the questions for the interview study and that the outcome of the latter in turn should complete the study *in situ*. Finally, we will carry out a complementary interview study.

The research groups chosen work in three experimental disciplines, two in biology and one in physics. They consist of 8 students and 6 supervisors. The groups have been selected in co-operation with the management of the university. The only demand we had on the groups was that they were to accept the necessary disturbance and encroachment during the three years of study. The groups that were proposed have all accepted our plans and they show great interest in our study. Other students have contacted us with comments on our work and have suggested students that ought to be interviewed in the separately planned interview studies. The number of students and supervisors that ought to be interviewed in this part has not yet been determined. Our expereince, however, is that appr. 20 from each category is an optimal number when intending to describe conceptions of a certain phenomenon.

We are still trying to find a final form for the participating studies. Both students and supervisors contribute to the data formation by keeping records of the event they find important for supervision and research, related to each student's work on his theses. They are given the biggest possible liberty to express their spontaneous experiences. Interviews about the content in these diaries are carried out in order to complete data.

Group discussions, and talks between supervisor and student about manuscripts, theses, problems in the studnet's work are recorded, and later commented on in diaries and interviews. Manuscripts in progress are gathered. The observer makes additional notes of the discussions. Several occassions have so far been recorded in the research groups concerned and conceptions based on the content in the student's work are expressed.

SCHEDULE

1983/84

1. To compile a literature study of research training.

2. To carry out pilot studies of the research groups, through participant observation, recordings of supervision and group seminars and collecting students' and supervisors' diaries. (So called process studies).

3. To elaborate questions for the first interview study. Both the results from the literature study and the process studies are taken into account.

4. To collect other information, e.g. on the external conditions for research training in the two disciplines.

1984/85

1. To continue the process studies as in 2) above. A number of interviews will be carried out with each student and supervisor, concerning events in the student's work, either observed in the laboratory, or focussed on in the diary, in the supervision or at the seminars.

2. To carry out the first interview study.

3. To continuously transcribe, process and analyse data.

4. To report preliminary results.

5. To work out questions for the second interview study, with a background in the process studies and the first interview study.

6. To collect views on the preliminary results from a group of experts.

7. To carry out the second interview study.

1985/86

1. To conclude the process studies and the second interview study.

2. To transcirbe, process and analyse data.

3. To compile the results and put them in a theoretical context.

4. To report the results.

SOMETHING ABOUT RELEVANT LITERATURE

In education

One could say that for the English post-graduate student the experience of supervision is that it is an apparent problem and a few studies have so far been published. Rudd (1975) interviewed 696 research students all over the country in different faculties. His data are detailed. His estimation is that 20-25% of the students are displeased with their supervision. Welsh (1978, 1979) used different methods for collecting data and made deep interviews with doctoral students at one university. It was possible to notice that the students in the natural sciences were less displeased. This could be explained by the close contact between student and supervisor in these experimental disciplines.

Welsh interviewed students as well as supervisors, while Rudd got in touch with people of great experience or of special interest. These studies are valuable as a complement to more content-related studies (see also Welsh, 1981a,b).

Walford (1979, 1980) studied doctoral students in physics. He asked them to keep diaries and he shows up aspects of the daily work and its problems and pleasures. Research is time-consuming, frustrating and sometimes boring. The student does a lot of the hard work. When an unexpected result shows up or a break-through takes place, the students experience periods of excitement and enjoyment. The point is, that students starting their training have an idealized picture of their coming role as researcher. There is a great rift between expectation and actuality. The student becomes a member of an existing research group in most cases, and takes part in solving shared problems. He will share instruments and take part in experiments and analyses of data. Gradually, the student is expected to contribute to the mass of knowledge. One could say that there is tension characterizing group activities and that this is a neglected area in research. (Walford, 1981).

Walford (1983) discusses the size of the research group and the group leaders' degree of participation in current experimental work with concepts as 'research state' and 'research style'. He also notices that studies have hitherto neglected to estimate students' contributions to research during their years of training.

Becher (1981a,b,c) have studied disciplinary cultures. He has interviewed scientists in biology, physics, history, sociology, law and technology on their views or conceptions of their own discipline's nature, questions on the theory of knowledge, the discipline as profession, as practice and researchers as people. He tries to depict different research styles. We could mention that Becher (1981a) interviewed 24 biologists and 20 physicists. Becher's (1981c) opinion is that an interviewbased approach is more productive than a technique with questionnaires.

Becher puts up a row of hypotheses of the scientists' conceptions. He claims that the typical approach of the physicist is pragmatic and ad hoc rather than philosophical. The physicist tries to find new mathematical tools to apply on different parts of physics and he also seeks new applications for existing equipment. In the physicist's arsenal the analogy is a fruitful weapon. Becher says about botanists and zoologists that they approach the problem in a way that they let hypotheses spring forth from data rather than formulating them from the beginning.

In psychology

The historical background and tendencies of research training in USA is dealt with in a book by Katz and Hartnett (1976). Katz points at some conditions for a student's suitable cognitive development. He also calls attention to the fact that what we need are *detailed descriptions of the problems of learning and the difficulties the students meet*. We also need to know how the students acquire study skills and how they understand and develop theories. Katz argues for studies in all disciplines. What he really says is that one should have a content-related perspecitve on these problems of research.

Hartshorn (Katz & Hartnett, 1976) describes what in retrospection could be called a 'mean day' in a concluded research training. In this study the students expressed their conceptions of such aspects as we are interested in.

One book by Mahoney (1976) is in many aspects complementary to Katz' and Hartnett's (1976). He deals with aspects close to questions treated in the theory and sociology of science. Mahoney (1979) claims that if we exclude studies of creativity, the psychology of research is on the whole delimited to some speculative and a few empirical studies.

Mahoney (1979) speculates over the fact that so few studies are done in the psychology of research. Do we really believe that we know how scientists behave? Scientists and teachers of science are consistent when describing aspects that characterize the ideal scientist. These aspects are:

1. *Objectivity* and emotional neutrality;
2. *Rationality* as evidenced by superior reasoning skills;
3. *Open-mindedness* (suspension of judgement and willingness to change one's opinion);
4. *Superior intelligence*;
5. *Integrity* in data collection and reporting; and
6. *Communality* (open and cooperative sharing of knowledge).

Mahoney critisises these points. The fact that they are so far unopposed has brought about unfortunate consequences a) through an inadequate evaluation of the relation between the ideal and

the real actions of the scientist, b) through the lack of an evaluation of the suitability and desirability of these ideals and c) through the lack of finding methods to refine scientific work and especially the human aspects of it.

Mahoney (1979) claims, that an adequate understanding of the human aspects of the scientific process demands a theoretical perspective which could only be given by psychologists. To use the methodological instruments of psychology is not enough. Fisch (1977) points out that the field uses diffuse and contradictory concepts. He agrees with Mahoney in trying to integrate the psychology of research with its sociological, historical and philosophical equivalents. In connection with this I wish to put attention to the essay "Forskningspsykologi" (Psychology of Research) by Bärmark (1983).

In the theory of science, the history of science, philosophy and sociology

Törnebohm's theory of science has been touched upon above. It has been practised in the project "Research roles and organisation of inter-disciplinary groups" supported by UHÄ (Bärmark & Wallén, 1980). Törnebohm's concept of paradigm has been applied in the UHÄ-project "Results of research training" (Odén, 1973, 1975, 1981; Thelander, 1979). These studies are relevant for our work. In connection with this we should mention that Holton (1981) among others points out that there is not much philosophical interest among the advocates for the process of discovery to understand this process as such and even less to describe the process of discovery.

Halldén (1980a) has used his philosophical perspective in the project "Critical schooling in higher education" (Halldén 1980b) and brought forth interesting issues which we should take a closer look at in our project. Halldén has several times pointed out that the scientist and the student could find himself in a kind of deadlock which is of psychological nature. We have already noticed this in the process studies.

Elkana (1972) has dealt with problems with a basis in the theory of knowledge in a historical perspective. He claims that today's Ph D dissertation which formerly was regarded as a genuine contribution to human knowledge has changed meaning. Nowadays it is considered immoral by the supervisor to let the student choose a problem to which the supervisor can't see at least a vague solution. The student usually doesn't choose the theme or the problem at large but this is chosen by the supervisor and is related to his interests and preferences. The student is not encouraged to start on original or speculatively penetrating studies. In this situation the student's independent intelligence will be in conflict with the supervisor's.

Fridjónsdottir (1982) has in her leaflet on the project "The Culture and Community of Research" treated several studies in

the theory and sociology of science, relevant to our project. We will not mention them here. Our projects will cooperate especially concerning methodological issues. However, I will mention a few studies in the field of sociology of science which directly affect our empirical studies.

Latour and Woolgar (1979) and Knorr-Cetina (1981) has carried out their sociological studies in laboratories. The latter focussed her studies on one special group. She assembled protocols, manuscripts, published results and interviewed researchers both from the group and outside. She observed and kept a record of her observations. She also recorded talks in the laboratory and in other places when something important seemed to happen and ought to be documented. Her studies concerning the writing of an article is especially interesting to us. These sociologists have approached the phenomenon at a content level. Salk says in the preface to Latour and Woolgar (1979) that the sociologists started to think like biologists after the long period in his laboratory. They point out themselves the importance of the content for a deeper understanding of the research process.

Studies of Williams and Law (1980) and Law and Williams (1983) show that the process leading up to a published article is worth looking closer at. The creation of an article is seen as a situation of negotiation between the scientists. In this process conceptions of knowledge and research are expressed, which is evident from recordings of the work with the manuscript. Knorr-Cetina (1981) has also in detail analysed a manuscript exposed to other scientists' criticism.

In 1974, the Nobel prize in physics was given to the Englishmen Sir Martin Ryle and professor A. Hewish. The latter was given the prize especially for his discovery of pulsars (radio astronomy). The student Jocelyn Bell was part of Hewish's research group and played a decisive role in the discovery. The circumstances caused great debate in the world of research and the written documentation is substantial.

Many sociologists of science have studied this event, i.a. through interviewing different persons around the event. One point here is that the scientists give different descriptions of the event in different situations and motivate them differently. These descriptions are contradictory. Another point is that the supervisor Hewish and the student Bell have contradictory conceptions of the same state of things. (Woolgar, 1976, 1980).

The results from the study of the discovery of pulsars are methodologically interesting. The scientists simply conceive of a phenomenon differently, the same scientist could as well express different conceptions of the same phenomenon at different times in written or oral form.

Mulkey and Gilbert (1983) have shown that scientists at different moments could give widely differing descriptions of their own approvals of a specific theory or of the nature of a choice of theory in their disciplines or in science at large. This concerns analyses of descriptions on a level between interviewdata and explanationsof the studied phenomena.

SCIENTIFIC AND PRACTICAL SIGNIFICANCE

It is obvious that the nature of supervision as a phenomenon in research training is a white spot on the map of knowledge. Many people carry a knowing of this phenomenon which they have not had the occassion to express in a way which transforms knowing to knowledge.

As far as I know the attitude employed in our studies is partly new, which should be scientifically interesting. The most important task is to problematize supervision and define the problems for continued scientific research on research training.

These studies are expected to contribute to the development of subject didactic theory and methodology, which is of importance to the educational system at large, for instance the development of didactics in teacher education.

There is a more and more intense debate on research, research training and supervision in progress in our country and elsewhere. This debate must be supplied with descriptions of how the training takes place and what it consists of on the level of interplay between supervisor and student. Such a debate is expected to lead to development work and in-service training to the gain of research training.

Leif Lybeck

1984-10-30

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